Research and Development on ECR Ion Sources

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Microwave tuning for metal ion production

It has been demonstrated that frequency tuning of the microwave injected into an ECR ion source (ECRIS) using a travelling wave tube amplifier (TWTA) can provide a considerable increase of the ion beam intensity of highly charged gas ions [1]. Investigations on the application of this technique on the production of metal ion beams have been performed with the CAPRICE ECRIS at the ECR injector test setup (EIS).

The standard Klystron microwave generator working at 14.5057 GHz has been replaced by a TWTA driven by a variable frequency synthesizer initially adjusted to the same frequency and operated at a forward power of 250 W. The ECRIS was operated with natural Ti evaporated from the high temperature oven (HTO) at a heating power of 230 W. After optimization of the ECRIS for stable ion beam conditions of Ti^{8+} the microwave frequency was swept in the frequency range from 12.5 to 16.5 GHz exhibiting a pronounced intensity variation of Ti^{8+} and Ti^{11+}, respectively, as shown in figure 1 for the ion current of Ti^{11+}. During the sweep some frequencies were identified at which this ion current was considerably enhanced. E. g. compared to the initial frequency of 14.5057 GHz which corresponds to an ion current of 13 µA of Ti^{11+} at 13.725 GHz an increase of the intensity level by a factor of 3 could be observed. Moreover the long time stability of the ion beam properties could be demonstrated in a 12 hours run. Only the oven heating had to be slightly adjusted in order to compensate for the reduction of sample material by the evaporation process.

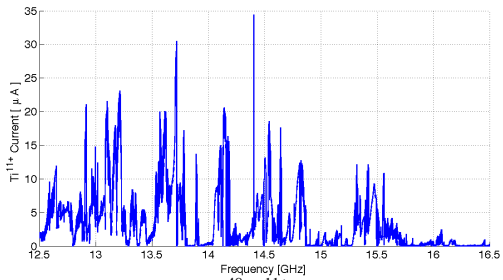

Figure 1: Variation of the $^{48}Ti^{11+}$ current as function of the microwave frequency.

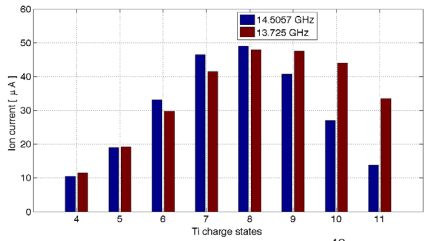

Figure 2: Charge state distributions of ^{48}Ti obtained for two microwave frequencies.

Figure 2 shows a comparison of the mass/charge spectra at these two selected frequencies. These spectra are obtained with identical source settings and oven heating. The shift of the charge state distribution, leading to a considerable intensity gain for the higher charge states, demonstrates that frequency tuning can be a versatile method to optimize for a suitable charge state distribution for the production of metal ion beams [2].

Pepper Pot emittance scanner devices

In the framework of a collaboration between the Kernfysisch Versneller Instituut (KVI) and GSI pepper pot emittance measurement devices have been designed and commissioned at KVI before installation at the EIS test setup at GSI. Such device utilizes a matrix of holes (10 µm diameter each) in a pepper plate which cuts beamlets out of the incoming ion beam. The local distribution of ion trajectories from the beamlets is collected and visualized by a sandwich MCP/phosphor screen. The image of the phosphor is recorded by a CCD camera and transformed into x−y coordinates. From the image data and from the original positions of the holes in the pepper plate the distribution of charged particle beams in the 4D transversal phase space can be evaluated. The evaluation method of such kind of device can account for the complex inhomogeneous structure of an ion beam originating from an ECRIS which is not possible with devices integrating over one space coordinate [3,4]. First tests were carried out with He and Ar beams. An optimization of the evaluation software is in progress.

Acknowledgements

The support of the European Union Seventh Framework Programme FP7/2007-2013 under Grant Agreement n° 262010 - ENSAR is acknowledged. The EC is not liable for any use that can be made on the information contained herein.

References

[1] F. Maimone, K. Tinschert, L. Celona, R. Lang, J. Mäder, J. Roßbach, and P. Spädtke, Rev. Sci. Instrum. 83, 02A304 (2012).

[2] K. Tinschert, R. Lang, J. Mäder, F. Maimone, J. Rossbach, Proc. of the 20th Workshop on ECR Ion Sources, Sydney, Australia, 25-28 Sept 2012.

[3] H. R. Kremers, J.P.M. Beijers, S. Brandenburg, Proc. of DIPAC 2007,Venice, Italy, p. 195.

[4] P. Spädtke, R. Lang, J. Mäder, F. Maimone, J. Roßbach, K. Tinschert, J.W. Stetson, Proc. of IPAC10, Kyoto, Japan, 2010, p. 4029